I. INTRODUCTION

EPA's Water Quality Criteria

EPA's Water Quality Standards regulations require states to adopt water quality criteria that will protect the designated uses of a water body. These criteria must be based on sound scientific rationale and must contain sufficient parameters or constituents to protect the designated uses. The criteria are the best estimate using available data. These data must be of the highest quality and reproducibility.

The methodology for developing water quality criteria was published by EPA in 1985. This original methodology is defined for criteria to protect aquatic organisms that inhabit the water column and the benthos. Exposure to chemicals is limited to passage of dissolved constituents through the gills. The criteria do not provide protection for ingestion of pollutants. They also do not account for site specific hydrological conditions, environmental chemistry of the medium or the organism tissue, extrapolation from laboratory data to field situations, water quality, temperature, dissolved oxygen, organic carbon, and relationships between species. Stresses by disease, parasites, predators, other pollutants, contaminated or insufficient food, and fluctuations and extreme conditions of flow, water quality, and temperature are not included as factors which may alter toxicity or exposure. Also, degradation of pollutants to more toxic forms is not taken into account. The criteria are therefore not protective of all species at all times and places. It is expected that as the data become available, additional criteria will be developed for multiple types of exposure.

A criterion is determined from laboratory toxicity studies including acute and chronic tests for aquatic organisms, toxicity tests for aquatic plants, and bioaccumulation studies for chemicals with known tissue residue effects. Acute toxicity studies are bioassays which are completed in less than 96 hours. The endpoints for acute tests are generally mortality and immobility. Chronic bioassays are assumed to be longer than 96 hours. The endpoints are generally sublethal.

The first step in deriving criteria is the calculation of the *Genus Mean Value.* This is based on the acute and chronic toxicity tests. The acute tests must include at least one species of freshwater animals in at least eight different families. These families must include 2 families from the class Osteichthyes along with 1 representative from each of the following : 1) the family Salmonidae, 2) the phylum Chordata, 3) a planktonic crustacean, 4) a benthic crustacean, 5) an insect, 6) a family in a phylum other than Arthropoda or Chordata, and 8) any phylum not represented. In addition, the acute to chronic ratios for species of aquatic animals must include at least three different families and including at least one fish, one invertebrate, and one acutely sensitive freshwater species. The *Final Acute Value* is derived from the cumulative distribution of the acute toxicity tests. The concentration at the cumulative probability of 0.05 is selected as the level which provides protection for a majority of species (95%).

Exposure

The criteria only account for one route of exposure: through the gills. They do not include exposures through ingestion. The variability in *magnitude, frequency,* and *duration* of exposure through the gills is included in the criteria.

Magnitude. The criteria contain two expressions of allowable magnitude: a *Criterion Maximum Concentration* to protect against acute (short-term) effects; and a *Criterion Continuous Concentration* to protect against chronic (long-term) effects. EPA derives acute criteria from 48- and 96-hour tests of lethality or immobilization. EPA derives chronic criteria from longer term (often greater than 28-day) tests that measure survival, growth, or reproduction.

Duration. The quality of an ambient water body typically varies in response to variations of effluent quality, stream flow, and other factors. Organisms in the water body do not typically receive constant, steady exposure but rather experience fluctuating exposures, including periods of high concentrations, which may have adverse effects. Thus, EPA's criteria indicate a time period over which exposure is to be averaged, as well as an upper limit on the average concentration, thereby limiting the duration of exposure to elevated concentrations. For acute criteria, EPA recommends an averaging period of 1 hour. That is, to protect against acute effects, the 1-hour average exposure should not exceed the criterion mean concentration. For chronic criteria, EPA recommends an averaging period of 4 days. That is, the 4-day average exposure should not exceed the criterion continuous concentration.

Frequency. To predict or ascertain the attainment of criteria, it is necessary to specify the allowable frequency for exceeding the criteria. This is because it is statistically impossible to project that criteria will never be exceeded. As ecological communities are naturally subjected to a series of stresses, the allowable frequency of pollutant stress may be set at a value that does not significantly increase the frequency or severity of all stresses combined.

EPA recommends the average frequency for excursions of both acute and chronic criteria not to exceed once in 3 years. In all cases, the recommended frequency applies to actual ambient concentrations and excludes the influence of measurement imprecision. EPA selected a 3-year average frequency of exceeding the criteria with the intent of providing for ecological recovery from a variety of severe stresses. This return interval is roughly equivalent to a 7 day average minimum flow expected every 10 years (7Q10) as a design flow condition. Because of the nature of the ecological recovery studies available, the severity of criteria excursions could not be rigorously related to the resulting ecological impacts. Nevertheless, EPA derives its criteria intending that a single marginal criteria excursion (i.e., a slight excursion over a 1-hour period for acute or over a 4-day period for chronic) would require little or no time for recovery. EPA thus expects the 3-year return interval to provide a very high degree of protection (EPA, 1994).

Idaho's Water Quality Standards

Since 1980, EPA has been publishing criteria development guidelines and national criteria for numerous pollutants. EPA's criteria documents provide a toxicological evaluation of the chemical, tabulate the relevant acute and chronic toxicity information, and derive the acute and chronic criteria that EPA recommends for the protection of aquatic life resources. States may choose to adopt EPA's recommended criteria or modify these criteria to account for site-specific or other scientifically defensible factors.

Section 303(c)(2)(E) of the Clean Water Act requires that all states adopt chemical-specific, numeric criteria for priority toxic pollutants. In 1992, the State of Idaho had not yet adopted such criteria. Therefore, on December 22, 1992, EPA promulgated such criteria for all waters in the State of Idaho as part of the National Toxics Rule (EPA, 1992). Idaho has since revised the Idaho Water Quality Standards to include the same criteria as EPA promulgated under the National Toxics Rule. Following completion of this consultation, EPA is proposing to recommend a federal action which would remove the State of Idaho from the National Toxics Rule, thus providing for the State's criteria to become effective.

The National Toxics Rule originally promulgated criteria for metals as total recoverable metals. Following EPA's promulgation of this rule, EPA issued a new policy for setting water quality criteria for metals. Therefore, on May 4, 1995, EPA issued a stay on the effectiveness of the metals criteria promulgated in the National Toxics Rule and promulgated revised criteria expressed in terms of dissolved metals (EPA, 1995). At this time, EPA also promulgated conversion factors for converting between dissolved and total recoverable criteria. States, when adopting criteria, may choose to adopt metals criteria measured as either dissolved or total recoverable. The metals criteria in the Idaho Water Quality Standards are expressed as dissolved metals.

In Idaho, both the aquatic life criteria and human health criteria apply to all surface waters of the State. Idaho's water quality standards contain a provision which states that when multiple criteria apply to a water body, the most stringent criterion is the applicable criterion. With regard to the numeric toxic criteria, most toxic pollutants have more stringent aquatic life criteria than human health criteria. Therefore, with regard to the majority of the toxic criteria, the aquatic life criteria are the applicable criteria for surface waters. An example of an exception to this generality is arsenic, where the human health criterion is lower (340 μg/L for aquatic life; 50 μg/L for human health) than the aquatic life criteria. Therefore, in all surface waters in Idaho, the applicable criterion for arsenic is the human health criterion.

All criteria in the Idaho Water Quality Standards, with the exception of the human health criterion for arsenic, are identical to the criteria promulgated by EPA under the National Toxics Rule. These criteria were adopted by reference in IDAPA 16.01.02.250.07. The aquatic life criteria evaluated as part of this assessment are summarized in Table 250.07.a.1. For comparison purposes, this table provides metals criteria expressed as both dissolved and total recoverable.

Idaho's criteria for pentachlorophenol (PCP) is expressed as an equation dependent on pH, while seven of the criteria for metals are expressed as a function of water hardness. The PCP criteria in Table 250.07.a.1 were calculated at a pH of 7.8. In Table 250.07.a.1, EPA used a hardness of 100 mg/L $CaCO_3$ in order to present a value for the metals criteria. The equations used to derive these criteria are presented in the footnotes to Table 250.07.a.1. These equations include the use of Water Effect Ratios, the ratio between site water and laboratory water effect levels. Water Effect Ratios default to 1, unless a state has done sufficient research to determine a ratio specific to a water body and adopted site specific criteria. Any adoption of site specific criteria must be approved by EPA and consulted on with the Services. Idaho's state standards currently apply the default Water Effect Ratios (see footnotes b and c in Table 250.07.a.1).

Table 250.07.a.1. Idaho Water Quality Standards General Aquatic Life Criteria (from 60FR22228)						
Chemical Name	Criteria (µg/L)		Total Recoverable Criteria (µg/L)		Conversion Factor[a]	
	Acute	Chronic	Acute	Chronic	Acute	Chronic
Arsenic	360	190	360	190	1.000	1.000
Cadmium	3.7[b]	1.0[b]	3.9[c]	1.1[c]	0.944[d]	0.909[c]
Copper	17[b]	11[b]	18[c]	12[c]	0.960	0.960
Cyanide	22[e]	5.2[e]	N/A		N/A	
Endosulfan (a & b)	0.22	0.056	N/A		N/A	
Lead	65[b]	2.5[b]	82[c]	3.2[c]	0.791[d]	0.791[c]
Mercury	2.1	0.012	2.4	0.012	0.85	N/A
Selenium	20	5.0	N/A		N/A	
Zinc	110[b]	100[b]	120[c]	110[c]	0.978	0.986
Aldrin	3	N/A	N/A		N/A	
Chlordane	2.4	0.0043	N/A		N/A	
Chromium (III)	550[c]	180[c]	1,700[c]	210[c]	0.316	0.860
Chromium (VI)	15	10	16	11	0.982	0.962
4,4'-DDT	1.1	0.001	N/A			
Dieldrin	2.5	0.0019	N/A			
Endrin	0.18	0.0023	N/A			
Heptachlor	0.52	0.0038	N/A		N/A	
Lindane (gamma-BHC)	2	0.08	N/A		N/A	
Nickel	1,400[b]	160[b]	1,400[c]	160[c]	0.998	0.997
PCBs	N/A	0.014	N/A		N/A	
Pentachlorophenol	20[g]	13[g]	N/A		N/A	
Silver	3.4[b]	N/A	4.1	N/A	0 .85	N/A
Toxaphene	0.73	0.0002	N/A		N/A	

N/A - no applicable criteria

a - Conversion factors for translating between dissolved and total recoverable criteria.

b - Criteria for these metals are expressed as a function of total hardness (mg/L as $CaCo_3$), and the following formula:

Acute Criteria = WER $\exp\{m_A[\ln(\text{hardness})]+b_A\}$ x Acute Conversion Factor

Chronic Criteria = WER $\exp\{m_C[\ln(\text{hardness})]+b_C\}$ x Chronic Conversion Factor

where (see following page):

Metal	m_A^f	b_A^f	m_C^f	b_C^f
Cadmium	1.128	-3.828	0.7852	-3.490
Chromium (III)	0.8190	3.688	0.8190	1.561
Copper	0.9422	-1.464	0.8545	-1.465
Lead	1.273	-1.460	1.273	-4.705
Nickel	0.8460	3.3612	0.8460	1.1645
Silver	1.72	-6.52	N/A	N/A
Zinc	0.8473	0.8604	0.8473	0.7614

The term "exp" represents the base e exponential function.

c - For comparison purposes, the values displayed in this table correspond to a total hardness of 100 mg/l $CaCO_3$ and a WER of 1.0.
d - The conversion factors for cadmium and lead are hardness dependent. The values shown in the table correspond to a hardness of 100 mg/L $CaCO_3$. Conversion factors for any hardness may be calculated using the following equations:

Cadmium:

Acute- CF=1.136672-[(ln(hardness))x(0.041838)]
Chronic- CF=1.101672-[(ln(hardness))x(0.041838)]

Lead:

Acute and Chronic- CF=1.46203-[(ln(hardness))x(0.145712)]

e - Criteria expressed as Weak Acid Dissociable
f - m_A and m_c are the slopes of the relationship for hardness, while b_A and b_C are the Y-intercepts for these relationships
g - Criteria for pentachlorophenol is expressed as a function of pH and calculated as follows:

Acute Criteria = exp(1.005 (pH) - 4.830)
Chronic Criteria = exp(1.005 (pH) - 5.290)

Water Quality Condition of Idaho Waters

The analyses for the protectiveness of numeric criteria assume that the organisms are exposed to concentrations of pollutants at the water quality criteria levels, not the conditions which currently exist in Idaho's waters. For waters that do not comply with the water quality standards, the State of Idaho and EPA are undertaking control actions to bring these waterbodies into compliance. However, due to the scale of the action that is the subject of this consultation and the temporal and spatial variability in water quality conditions throughout the state, this assessment will only analyze potential effects at the criteria concentrations. EPA realizes that the analysis is conservative on the side of the species for the majority of the state's waters which contain pollutant concentrations well below the criteria levels. Where waters are not currently in attainment of the standards but where actions are in place to remedy current water quality problems, the analysis describes desired future conditions and thus underestimates potential current effects on the species of concern.

II. METHODS FOR DETERMINATIONS

Determinations regarding the potential for the criteria established by the Idaho Water Quality Standards to adversely affect threatened and endangered species were based on an analysis of the existing criteria documents and any new literature published after the criteria document publication. Acute criterion were compared to published toxicity data where exposure durations were less than or equal to 96 hours. Chronic criterion were compared to published toxicity data where exposure durations were greater than 96 hours. While the scientific community does not agree on precise definitions for the terms acute and chronic, the general approach used here can offer an adequate assessment of the criteria's potential effects on aquatic species.

For all aquatic species except sturgeon, a "may be likely to adversely affect" determination was made if 1) no information was available detailing the toxicity of the chemical with regard to the species of concern or a reasonable surrogate, or 2) the published toxicity data indicated adverse effects at concentrations at or below the established criteria. A "not likely to adversely affect" determination was made if the published toxicity data indicated adverse effects at concentrations above the established criteria. Adverse effects on species were divided into sublethal and lethal effects. Sublethal effects included any measurable or observable effect on a species, not including mortality, while lethal effects consisted only of mortality. Both lethal and sublethal effects were evaluated for each criterion. Generally, in an effort to refrain from duplicating previous work, reports reviewed for this document were published after the publication of EPA's criteria documents for the chemicals reviewed here. Most of the criteria documents were published between 1980 and 1985. In some cases, where information was lacking, we have included data published prior to the criteria documents.

Rather than taking the default approach and assigning a 'likely to adversely affect" determination for white sturgeon, we have chosen to evaluate the proposed standards by examining toxicity data for a variety of fish species, including cold water species (e.g. salmonids) and benthic species (e.g. catfish). If the proposed standards are protective of a variety of fish species, we can assume that the standards will also adequately protect white sturgeon for the following reasons: 1) the proposed standards are below the limits for other fish species and 2) the limited data available show that sturgeon have variable sensitivity compared to other species (i.e. they are not consistently more sensitive than other species).

Of the priority pollutants with Aquatic Life Criteria (see list below), it was jointly determined by EPA and the Services that some chemicals required a more detailed analysis. EPA examined the effects of nine chemicals: arsenic, cadmium, copper, lead, mercury, selenium, zinc, and cyanide, in more detail due to their prevalence in Idaho waters. Endosulfan was also addressed in more detail because of its current agricultural use in Idaho. Chromium III, chromium VI, nickel, silver, and Heptaclor/Heptachlor Epoxide were provided a minimal level of analysis because these chemicals do not occur in Idaho waters with the same regularity. The remaining 9 organic chemicals listed were also given a minimum level of analysis since their use has either been canceled or suspended. For those chemicals given a minimum level of analysis, EPA primarily relied upon information provided in EPA's water quality criteria guidance documents (1980-1985).

For each of the chemicals receiving a high level of analysis, the determination section is organized as described here: a preliminary description of the chemical and criteria followed by an evaluation of recent research on each of the species of concern or their surrogates. The species are considered together in phylogenetic groups such as invertebrates, fish, and birds. Within the evaluation for invertebrates and fish, sublethal and lethal effects are evaluated separately. Determinations for the chemicals that received a minimal level of analysis are grouped together at the end of this section. For each of these chemicals, some background information is provided along with an effects determination. For wildlife and plants, a more general analysis based on exposure is provided in the following sections. A summary of all determinations for all threatened and endangered species is presented in this section. The detailed analysis of effects to fish and invertebrates is presented in Chapter 3.

Priority Pollutants for Aquatic Life Criteria

Tier I - High level of analysis	Tier II - Low level of Analysis	
Arsenic	Chromium (III)	4-4'DDT
Cadmium	Chromium (VI)	Dieldrin
Copper	Nickel	Endrin
Lead	Silver	PCB Arochlors
Mercury	Heptachlor/Heptachlor	Toxaphene
Selenium	Pentachlorophenol	
Zinc	Aldrin	
Cyanide	gamma-BHC (Lindane)	
alpha and beta Endosulfan	Chlordane	

Biological Uptake, Bioaccumulation, Bioconcentration, Biomagnification

The following definitions are provided to explain EPA's determinations regarding biological uptake of chemicals. Bioaccumulation is defined by Rand (1995) as the "...process by which chemicals are taken up by aquatic organisms directly from water as well as through exposure through other routes, such as consumption of food and sediment containing the chemicals." Alternatively, Rand (1995) describes bioconcentration as the "... process by which there is a net accumulation of a chemical directly from water into aquatic organisms..." Since determining the source of chemical accumulation in tissues is difficult at best when reviewing literature, these terms are used somewhat interchangeably to mean an observed increase in tissue concentration of a substance in relation to the concentration in the water. In determining sublethal effects to invertebrates and fish, EPA has concluded that bioconcentration or bioaccumulation is an indicator of exposure to chemicals, but will not be classified as an effect. The concentration of chemicals in tissues of aquatic organisms can be an excellent indicator of environmental exposures, but bioconcentration alone does not constitute an effect to an organism. Effects may occur as a result of the bioconcentration. Where the studies reviewed for this document illustrated effects coincident with bioconcentration, we have included that information in the sections detailing effects to organisms. Otherwise, when the results of the studies reviewed included only bioconcentration of contaminants, information regarding those studies was described in the "Bioconcentration and Biomagnification" sections for each chemical.

Rand (1995) defines biomagnification as the "result of the processes of bioconcentration and bioaccumulation by which tissue concentrations of bioaccumulated chemicals increase as the chemical passes up through two or more trophic levels." Rand further states that the transfer of chemicals from food to consumer are efficient enough so that residue concentrations icrease systematically from one trophic level to the next. EPA considers biomagnification to increase the risk of adverse effects of waterborne chemicals, but demonstration of biomagnification alone is not classified as an effect to listed species.

III. ANALYSIS OF EFFECTS OF TOXIC POLLUTANTS TO WILDLIFE

Mammals

Woodland caribou, northern Idaho ground squirrels, and grizzly bears in Idaho are primarily vegetarians (Almack, 1985; FWS, 1994c). Gray wolves and lynx consume prey that are primarily vegetarian. These mammals should not be exposed to harmful concentrations of toxic pollutants as a result of exposure to contaminated aquatic organisms since they do not consume fish. Their primary route of exposure is through ingestion of water. Bald eagles and peregrine falcons do consume fish on a regular basis and may be exposed to aquatic contaminants through dietary exposure.

Water quality criteria for human health were considered to be protective of all threatened and endangered mammals. The human health criteria protect against long term health effects. These effects range from cancer to reproductive and neurological impairments. The toxicity endpoints are related to human health, however these endpoints are usually derived from laboratory studies of rats and mice. This interspecies extrapolation for all mammals is accounted for in the modifying factors used to derive the toxicity endpoints.

The exposure equation used to derive the criteria for non-carcinogenic effects is:

$$C = \frac{(RfD \times WT) - (DT + In) \times WT}{WI = (FC \times L \times FM \times BCF)}$$

C = updated water quality criterion (mg/L)
RfD = oral reference dose (mg toxicant /kg human body weight/day)
WT = weight of an average human adult (70kg)
DT = dietary exposure (other than fish) mg

toxicant/kg body weight/day)
IN = inhalation exposure (mg toxicant/kg body weight/day)
WI = average human adult water intake (2 l/day)
FC = daily fish consumption (kg fish/day)
L = ratio of lipid fraction of fish tissue consumed to 3%
FM = food chain multiplier (from Table 3-1)
BCF= bioconcentration factor (mg toxicant/kg fish divided by toxicant/L water) for fish with 3% lipid content.

While the exposure assumptions for developing the human health criteria used to estimate risks are based on human data, these assumptions should apply to any mammal with a body weight of 70 kg (as body weight decreases, exposure increases), a drinking water consumption rate of 2 liters per day, and a fish consumption rate of 6.5 g per day. The exposure duration for non-cancer endpoints will vary depending on the chemical effect and the condition of the population at risk. The exposure duration for carcinogens is 70 years. Since, the exposure assumptions for the mammals other than humans is unknown there is additional uncertainty which may increase or decrease the risk for these species.

The possibility of exposure to toxic pollutants via contamination of plant materials in aquatic systems is unlikely as well. Generally, the herbivorous species do not feed in or very near to aquatic habitats. Biomagnification through plants directly to mammals is uncommon. From this information, EPA has determined that the approval of the **acute and chronic numeric criteria for toxic pollutants** established by the Idaho Water Quality Standards **is not likely to adversely affect the gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, and woodland caribou.**

Birds

Several models were examined to determine dietary levels of toxicants in organisms exposed to parameters at the adopted water quality criteria concentrations. Often, a model requires wildlife values that are unavailable for the species of concern, or the concentration of the chemical in the sediment is needed. For fish, even if a BCF or BAF is available for a particular species, the wildlife value may not be available. Also, the more complicated models require many assumptions that can cover a wide range. For example, feeding rates, amount of diet comprised of a "contaminated" food source, potential food source trophic levels, metabolic rates, and sensitivity factors can vary by orders of magnitude. The lowest tissue concentration of a chemical in the diet that will not cause adverse effects, the NOAEL, is also expressed as "wildlife value" or "body burden". These wildlife values can cover a large range for the same organism depending on the researcher's assumptions. Given the latitude in variables such as those mentioned above and the specific requirements of the food chain/wildlife models, a general approach was chosen to estimate effects on birds. The example at the end of this section shows this approach. To estimate the effects of an adopted water quality criterion on "higher" organisms, raptors were selected. Specifically, the bald eagle and peregrine falcon are species of concern. The bald eagle and peregrine falcon are both listed under the Endangered Species Act (ESA) for Idaho. For the higher priority chemicals, no wildlife-diet values are available for these bird species. Wildlife values for other bird species or alternately, general wildlife values are available. For many of the parameters of concern, BAFs/BCFs are available for fish, or more specifically, for trout. Since eagles may feed at least somewhat on fish, if a fish BAF is available for a particular parameter, then a general wildlife exposure to an eagle can be estimated for that parameter. BCFs in aquatic life allow for the general approach presented below (that is, substituting a BCF for lack of a BAF). EPA made the conservative assumptions of a 100 percent fish diet and that all fish eaten were contaminated.

Equation to estimate toxicant exposure to birds through diet:

toxicant (mg/L) X BCF or BAF (mg/kg in fish/ mg/L in water) = mg/kg in diet (assuming 100% fish diet)

IV. ANALYSIS OF EFFECTS OF TOXIC POLLUTANTS TO PLANTS

The four threatened or endangered plant species in Idaho do not exist in areas constantly inundated by water, therefore the effects of aquatic contaminant exposure should be minimal. The Ute ladies' tresses is a terrestrial orchid species that is only periodically exposed to surface waters. This species generally inhabits river shores where inundation occurs infrequently (Sheviak, 1984). McFarlane's four o'clock, also a terrestrial plant species, occurs in grassland habitats characterized by warm and dry conditions (FWS, 1997b). Exposure to surface water would generally occur in these areas only during rare flooding events when dilution of contaminants and length of exposure to contaminated water would minimize toxicity. Water howellia, an aquatic macrophyte, grows mostly in wetlands associated with temporary water bodies such as ephemeral glacial pothole ponds and former river oxbows (FWS, 1994b). This plant requires the seeds to dry out completely for germination to occur. The Spalding's catchfly primarily inhabits prairie or steppe grassland vegetation and does not tolerate extremely wet soils. Therefore, because of the lack of exposure to contaminants in aquatic systems, EPA has determined that the approval of the **acute and chronic numeric criteria for toxic pollutants** established by the Idaho Water Quality Standards **is not likely to adversely affect the water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's Catchfly.**

V. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, Tribal, local or private actions on endangered or threatened species or critical habitat that are reasonably certain to occur in the action area considered in this biological assessment. Future federal actions or actions on federal lands that are not related to the proposed action are not considered in this section .

Future anticipated non-Federal actions that may occur in or near surface waters in the State of Idaho include timber harvest, grazing, mining, agricultural practices, urban development, municipal and industrial wastewater discharges, road building, sand and gravel operations, introduction of nonnative fishes, off-road vehicle use, fishing, hiking, and camping. These non-Federal actions are likely to continue to adversely affect endangered and threatened species.

There are also non-Federal actions likely to occur in or near surface waters in the State of Idaho which are likely to have beneficial effects on the endangered and threatened species. These include implementation of riparian improvement measures, best management practices associated with timber harvest, grazing, agricultural activities, urban development, road building and abandonment and recreational activities, and other nonpoint source pollution controls.

VI. CRITICAL HABITAT

The only listed species with designated critical habitat in Idaho are the Snake River spring/summer chinook salmon, Snake River fall chinook salmon, and Snake River sockeye salmon.

Description of Salmon Critical Habitat

NMFS has designated critical habitat in Idaho for Snake River spring/summer chinook salmon, Snake River fall chinook salmon, and Snake River sockeye salmon. As required by Section 7 of the ESA and the implementing regulations at 50 CFR Part 402, EPA has used the best available scientific data to determine whether the action is likely to "destroy or adversely modify the designated critical habitat of the listed species". The consultation regulations define the statutory term "destruction or adverse modification" of critical habitat to mean:

> *...a direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species. Such alterations include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining the habitat to be critical.*

The Federal Register (Vol 58 No. 247, December 28, 1993) final rule designates critical habitat and defines and describes habitat and its essential features as follows:

> *Essential Snake River salmon habitat for both chinook and sockeye consists of four components: 1) spawning and juvenile rearing areas, 2) juvenile migration corridors, 3) areas for growth and development to adulthood, and 4) adult migration corridors.*

Spawning and rearing areas:

The essential features of the spawning and juvenile rearing areas of the designated critical habitat for Snake River sockeye salmon consist of adequate: 1) spawning gravel, 2) water quality, 3) water quantity, 4) water temperature, 5) food, 6) riparian vegetation, and 7) access.

The essential features of the spawning and juvenile rearing areas of the designated critical habitat for Snake River spring/summer and fall chinook salmon are: 1) spawning gravel, 2) water quality, 3) water quantity, 4) water temperature, 5) instream cover/shelter, 6) food for juvenile salmon, 7) riparian vegetation, and 8) living space.

Migration corridors:

Essential features of the juvenile migration corridors for Snake River sockeye salmon and Snake River spring/summer and fall chinook salmon consist of adequate: 1) substrate, 2) water quality, 3) water quantity, 4) water temperature, 5) water velocity, 6) cover/shelter, 7) food, 8) riparian vegetation, 9) space, and 10) safe passage conditions.

Essential features of the adult migration corridors for Snake River sockeye salmon and Snake River spring/summer and fall chinook salmon include adequate: 1) substrate, 2) water quality, 3) water quantity, 4) water temperature, 5) water velocity, 6) cover/shelter, 7) riparian vegetation, 8) space, and 9) safe passage conditions.

Growth and Development:

The areas in the Pacific Ocean that threatened and endangered salmon use for growth and development are not well understood; therefore, NMFS has not designated any essential areas and features for Snake River ocean habitat.

Analysis of Effects of Criteria for Toxic Pollutants on Salmon Critical Habitat

To determine whether EPA's approval of Idaho's numeric criteria for toxic pollutants is likely to adversely affect critical habitat, EPA has identified possible threats to the essential features of habitat. In evaluating the effects of the action on critical habitat, EPA concluded that the water quality parameters considered in this consultation are an integral part of all the species' habitats. Chapter 3 of this document presents information describing the analysis of effects of specific water quality criteria to Snake River salmon.

Water quality standards for toxic chemicals characterize and define the conditions and quality of surface waters. EPA's approval of Idaho's water quality standards may directly and/or indirectly affect spawning gravels and food which are essential features of salmon habitat.

The concentration of toxic chemicals in the water column should not affect the following essential features of critical habitat: temperature, water quantity, riparian vegetation, access, instream cover/shelter, space, safe passage conditions, water velocity and substrate. Therefore, **EPA's approval of Idaho's numeric criteria for toxic pollutants addressed in this biological assessment is not likely to adversely affect these essential features of critical habitat of Snake River salmon.**

Spawning gravels. Toxic chemicals may sorb to sediments and accumulate in the benthic areas of water bodies. These can remain as potential sources or sinks for pollutants. EPA is in the process of developing sediment criteria for toxic chemicals. These criteria should provide additional protection for salmon habitat. In addition, criteria which limit the quantity of settleable solids will provide additional means for reducing exposure of fish to contaminated gravel beds. Gravel, being coarse and low in organic matter does not tend to accumulate either organic pollutants or metals.

Food sources. Based on the available information, this analysis indicates that the chronic mercury criterion and chronic selenium criterion may have the potential to adversely affect Snake River salmon. Because the criteria set the allowable concentrations of these pollutants in surface waters in Idaho, EPA has determined that the approval of these criteria may have the potential to affect food in critical habitat.

The effect of consuming contaminated food is discussed in the "Biomagnification and Bioaccumulation" section for each water quality criterion. The decline of prey due to exposure to toxic chemicals impacts growth, reproduction, and survival of prey species. The effect of the decline of individual prey species on food supply is unknown. Without this information, EPA is unable to determine whether this may have the potential to adversely affect food as an essential feature of critical habitat.

Research does document mercury and selenium biomagnification in aquatic food chains (Lemly and Smith, 1987; Lemly, 1985; Wren and MacCrimmon, 1986). Therefore, Snake River salmon may encounter harmful concentrations of mercury and selenium through biomagnification of these chemicals through prey. However, the efficiency of metal transfer through macroinvertebrates may not allow absorption of metal concentrations high enough to harm the fish (Reinfelder and Fisher, 1994). No evidence has been found describing effects to salmon through biomagnification of mercury and selenium in the food.

Determination

Although the above analysis indicates that Idaho's chronic criteria for mercury and selenium may have the potential to affect food as essential features of critical habitat, these effects alone would not be significant enough to appreciably diminish the value of critical habitat for both the survival and recovery of Snake River salmon.

Although the potential may exist for some elements of critical habitat to be adversely affected, other elements are not likely to be affected. Consequently, these effects are not likely to "result in significant adverse effects throughout the species' range or appreciably diminish the capability of the critical habitat to satisfy essential requirements of the species". Therefore, **EPA has determined that the approval of**

these provisions is not likely to destroy or cause an adverse modification to designated critical habitat of the Snake River sockeye, Snake River spring/summer chinook salmon, and Snake River fall chinook salmon.

The analysis in Chapter 3, indicates that all remaining numeric toxic criteria which were evaluated were not likely to adversely affect Snake River salmon. **Therefore, these remaining criteria are not likely to adversely affect water quality or food as essential features of critical habitat of Snake River salmon.**

VII. SUMMARY OF DETERMINATIONS FOR INVERTEBRATES, FISH, WILDLIFE AND PLANTS

The following determinations of "not likely to adversely affect" were made:

Aldrin/Dieldrin, Chlordane, Chromium III and VI, DDT, Endrin, Heptachlor, Lindane, Nickel, PCBs, Pentachlorophenol, Silver, Toxaphene: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, Kootenai River white sturgeon, bull trout, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, bald eagle, peregrine falcon, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, whooping crane, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

Acute Arsenic Criteria: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, Kootenai River white sturgeon, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, bull trout, bald eagle, peregrine falcon, whooping crane, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

Chronic Arsenic Criteria: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, Kootenai River white sturgeon, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, bull trout, bald eagle, peregrine falcon, whooping crane, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

Acute and Chronic Cadmium Criteria: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, Kootenai River white sturgeon, bull trout, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, bald eagle, peregrine falcon, whooping crane, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

Acute and Chronic Copper Criteria: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, Kootenai River white sturgeon, bull trout, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, bald eagle, peregrine falcon, whooping crane, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

Acute and Chronic Cyanide Criteria: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, Kootenai River white sturgeon, bull trout, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, bald eagle, peregrine falcon, whooping crane, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

Acute and Chronic Endosulfan Criteria: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, Kootenai River white sturgeon, bull trout, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, bald eagle, peregrine falcon, whooping crane, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

Acute and Chronic Lead Criteria: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, Kootenai River white sturgeon, Kootenai River white sturgeon, bull trout, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, bald eagle, peregrine falcon, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, whooping crane, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

Acute Mercury Criteria: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, Kootenai River white sturgeon, bull trout, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, bald eagle, peregrine falcon, whooping crane, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

Chronic Mercury Criteria: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, Kootenai River white sturgeon, bull trout, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

Acute Selenium Criteria: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, Kootenai River white sturgeon, bull trout, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, bald eagle, peregrine falcon, whooping crane, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

Chronic Selenium Criteria: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

Acute and Chronic Zinc Criteria: Bliss Rapids snail, Banbury Springs lanx, Snake River physa snail, Idaho springsnail, Bruneau hot springsnail, Utah valvata snail, Kootenai River white sturgeon, bull trout, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, bald eagle, peregrine falcon, whooping crane, gray wolf, grizzly bear, lynx, Northern Idaho ground squirrel, woodland caribou, water howellia, MacFarlane's four o'clock, Ute ladies' tresses, and Spalding's catchfly.

The following determinations of "likely to adversely affect" were made:

Chronic Mercury Criteria: peregrine falcon, bald eagle, and whooping crane.

Chronic Selenium Criteria: Kootenai River white sturgeon, bull trout, Snake River sockeye salmon, Snake River spring/summer chinook salmon, Snake River fall chinook salmon, Snake River steelhead, peregrine falcon, bald eagle, and whooping crane.

VIII. UNCERTAINTY ANALYSIS

Water quality criteria are designed to provide protection at a large scale. They are not designed to fit all conditions and all species. Since these are generic rather than specific criteria they include a number of assumptions, defaults, and simplifications which results in some uncertainty in EPA's determinations. These uncertainties are divided into 5 categories: generic criteria, surrogate species, sensitivity of different life stages, loss of prey species, dietary exposures, bioavailability, sediment exposures, chemical mixtures, and background water quality conditions including temperature, dissolved oxygen, alkalinity, conductivity, total dissolved solids, carbon, pH, and hardness.

Generic criteria

EPA's use of combined interpretation of all relevant data under a standard methodology is an attempt to reduce uncertainty in study design or results. However, this may result in the elimination of single studies which may identify critical pathways of exposure or toxicological endpoints not accounted for by the method of combining study results. In an attempt to assure high quality data are included in this combined approach, EPA's method may eliminate the lowest effect concentration reported in the literature.

Surrogate species

The analysis of the potential effects of toxic pollutants on threatened and endangered species included the examination of research conducted primarily with surrogate species. The surrogate species were selected as the closest related organism for which information was available. The best surrogates would live in the same environment and consume the same food as the listed species. For example, little research exists describing the effects of toxic chemicals on chinook and sockeye salmon, but a wealth of information exists describing the effects of toxic chemicals on rainbow trout. Therefore, rainbow trout often served as a surrogate species to determine the effects of toxic pollutants on chinook and sockeye salmon.

Sensitivity of different life-stages

Sublethal effects of toxicant exposure on multiple life stages of salmonids have not been completely identified. For returning spawning adults, the potential effects on the population could be quite large and catastrophic. Some potential effects include disruption of reproductive cues or migration. The development of the criteria involved data on rainbow trout at a few life stages under acute exposures. The potential effects of some chemicals to different salmonid life stages have not been fully evaluated, and this lack of evaluation does limit the accuracy with which we may estimate the protection offered by the criteria. Further research into the effects of contaminants on all salmonid life stages is needed.

Loss of Prey Species

The analysis of the criteria did not address the effects of the criteria on prey items of individual species or on their habitat beyond the water column. Toxic chemicals may affect aquatic organisms via ingestion (of contaminated prey or sediment particles) or through absorption (from water or from sediment). Furthermore, prey populations may decrease as a result of chemical contamination, thus depriving a species of food sources. The development of the criteria included effects for many prey species and should adequately protect prey of the listed species examined in this document.

Dietary exposures

Many fish species are among the top consumers in aquatic ecosystems, and as a result, diet-borne pollutants can represent a unique hazard as they are transferred through the food chain. Exclusive use of water column criteria (either dissolved or total recoverable) may underestimate the toxicity of an aquatic system by excluding ingestion of particulates or ingestion of prey that consume particulates as a pathway for toxic chemical exposure. Evidence for ingestion of prey as an exposure pathway has been discussed by Kiffney and Clements (1993). Studies have correlated metal-contaminated diets with adverse effects on salmonids (Woodward et al., 1994; Farag et al., 1994; Woodward et al., 1995). Dallinger et al. (1987) also describes a "food chain effect," where metal-impacted systems may become dominated by metal-tolerant prey organisms, such as certain aquatic invertebrates. These invertebrates tolerate high metals concentrations by storing metals in vacuoles. Fish may be negatively affected by consuming the metal-rich prey. Evidence for the "food-chain effect" is provided by Woodward et al. (1994). The application of water column criteria is intended to protect water column organisms from exposure to metals from the water column. Little connection exists between the establishment of water column concentrations to protect against toxicity to aquatic organisms and the degree to which metals might accumulate in sediments and/or accumulate in benthic organisms that serve as prey for fish and other organisms. The existence and extent of metal accumulation in sediments is dependent on site-specific physical and chemical conditions. Accordingly, the degree of metal accumulation can not be inferred from water column criteria, whether total or dissolved. EPA recognizes that there is residual uncertainty regarding dietary metal exposure.

Research is needed to better understand the relative importance of food versus water in the transfer of metals to juvenile salmonids and in the development of toxic effects associated with uptake of metals. Other tools that could increase protection of endangered species from the threat of dietary exposure would be the development of sediment criteria, wildlife criteria, and bioaccumulation indicators.

Bioavailability

Bioavailability of individual compounds was based on the likelihood of biological uptake from the water column. Organic chemicals were measured as total chemical since it is believed that all forms of the chemical are bioavailable regardless of partitioning into dissolved or particulate phase.

Metals in the water column will also partition into a solid or particulate phase depending on the sorption properties of the metal and particulate materials as well as the chemical condition (pH, etc) of the surrounding water. Scientists consider metal sorbed to sediments to be unavailable for biological uptake through the gills (Bergman and Dorward- King 1997).

As is the case with many scientific issues, EPA recognizes that it would be optimal to undertake additional study to better define the relative importance of particulate-bound metal. If such work were to indicate that the particulate pathway was significant compared to the dissolved pathway, the EPA would need to determine how to revise its procedures for deriving aquatic life criteria to account for this pathway. Currently, there is no scientific consensus on how to do this.

Sediment exposures

To protect the benthos against toxicity due to metals contamination of sediments, EPA has developed an Equilibrium Partitioning Sediment Guideline. To improve the accuracy and reliability of its water quality criteria, EPA is developing a Biotic Ligand Model to evaluate aquatic life exposure to metals via membranes (i.e. gills) in contact with the water.

Chemical Mixtures

The Idaho Water Quality Standards aquatic life criteria do not take into account the interactions between two or more chemicals which could be present in a water body. Some chemicals may interact resulting in more or less toxicity of one or more of the chemicals involved. Some metals such as cadmium and selenium exhibit antagonistic relationships with respect to toxicity. The literature provides little evidence to indicate synergistic interactions between metals (Furness and Rainbow, 1990). Synergism is defined as the interaction of toxicants resulting in greater toxicity than that predicted by the sum of the toxicities of each chemical. However, pollutant discharges such as those released by permitted dischargers are unique mixtures of elements. Research studies generally focus on the most abundant elements without reference to others present in a complex mixture. Synergistic, antagonistic, and additive biological effects are possible for fish exposed to mixtures. Categorizing elemental mixtures as synergistic, antagonistic, or additive depends on the element concentrations, solubility, and ratios to other elements, as well as the water hardness, measured parameters, species considered, and other factors (Sorenson, 1991).

One way to account for the interactions of contaminants is to use the Toxic Unit approach (see Pulley et al., 1998 and Wildhaber and Schmitt, 1998 for examples) or the Hazard Quotient method (US EPA, 1997). On a statewide basis, this approach would be neither practical nor relevant; however, on a site-specific basis, mixtures can be defined.

Background water quality conditions

Toxicity of several pollutants for which criteria are included in the Idaho Water Quality Standards are either pH or hardness dependent. In these cases, the State's criteria are expressed as a function of pH or hardness. However, in many cases, the literature does not report the environmental conditions under which toxicology experiments have been performed, including pH and hardness. Where relevant, EPA's analysis took into account whether pH and hardness values were provided. Where pH and hardness values were not reported in the literature and the criteria are expressed as a function of pH or hardness, the results should be interpreted with caution.

EPA has considered hardness to represent not only calcium and magnesium, also to be a surrogate for two other parameters, alkalinity and pH, which co-vary with hardness in natural waters. Current thinking is that the hardness relationships work primarily through the combined effects of calcium, carbonate, and pH. However, until the development of the biotic ligand model, it has not be feasible to isolate the separate effects of these parameters. The biotic ligand model will allow more accurate prediction of toxicity in waters having unusual combinations of hardness, alkalinity, and pH.

Hardness cap for metals criteria. In the NTR, EPA described and required minimum and maximum hardness values (25 mg/L and 400 mg/L as $CaCO_3$, respectively) to be used when calculating hardness dependent freshwater metals criteria. Most of the data EPA used to develop the criteria formulas were in the hardness range of 25 to 400 mg/L. Therefore, EPA stated that the formulas were most accurate in that range. Using a hardness of 25 mg/L for calculating criteria, when the actual ambient hardness is less than 25 mg/L, could result in criteria that are not protective of aquatic life. The State has the option of using ambient hardness values outside the 25-400 mg/L range when calculating criteria for hardness dependent metals.

For reference, average, minimum, and maximum hardness measurements recorded in waters throughout the State of Idaho are presented in Appendix F. Hardness values observed throughout the State range from 14.07 mg/L in the Upper Selway River to 404 mg/L in the Lower Bear River, with an average of 103.8 mg/L. Literature describing the experiments referenced in this section did not always provide hardness values along with data. In cases where hardness values are lacking, comparisons of criteria to research results may not be reliable. For those metals which are hardness dependent, EPA Region 10 calculates NPDES permits limits and load allocations for TMDLs using the fifth percentile of the ambient and or effluent hardness values which are most often calculated from instantaneous data. When coupled with the rare low flow event, this yields a very conservative, highly protective result.

pH. The toxicity of several pollutants vary depending upon environmental conditions such as water hardness and pH. pH activity has a significant impact on the availability and toxicity of metals. The following is summarized from Elder (1988) and Baker et al. (1990) IN ODEQ (1995). Metal-hydroxide complexes tend to precipitate (i.e., reduced ability to remain suspended) and are quite insoluble under natural water pH conditions; thus, the metal is not able to exert a toxic effect. However, the solubility of these complexes increases sharply as pH decreases. pH activity also impacts the sensitivity of organisms to a given amount of metal. Each metal has its own range where pH and site-specific conditions become factors in the metal's bioavailability. Aluminum is the metal of greatest concern at low pH values. The effects of low pH are also more pronounced at low concentrations of calcium. No adverse effects to listed species due to pH-driven changes in metal toxicity (where the metals comply with the respective metals criteria) would occur in the range of Idaho's pH criteria. In summary, reductions in pH below natural levels will tend to increase metal availability and toxicity.

Temperature. No single pattern exists for the effects of temperature on the toxicity of pollutants on aquatic organisms. Temperature change in a given direction may increase, decrease, or cause no change in toxicity depending on many factors including the toxicant, species, or the experiment. Sprague (1985) demonstrates that the effects of temperature on acute toxicity are diverse, but for the most part are only small or moderate. Some evidence suggests that temperature may not have much effect at all on the chronic "no-effect" thresholds of pollutants. One study described that temperature may either increase or decrease the EC_{50}, but no general pattern was evident. The researchers concluded that temperature had no effect on the EC_{50} (Sprague, 1985).

pH and temperature effects on cyanide. The maximum temperature allowed by Idaho's water quality standards is 33°C (warm water biota), while the pH criterion requires that surface waters fall within a range of 6.5-9.0. Below a pH of 9.2 CN^- increasingly converts to HCN until, at a pH of 7.0, nearly all free cyanide exists as HCN. However, below pH of 8, only about 6% of total cyanide is present as free cyanide, thus any increase in cyanide toxicity due to free cyanide will be minimal (Stein, personal communication, 2000). Eisler (1991) also notes that the toxicity of simple cyanide complexes will not be measurably affected below pH 8.3. Acidification of dilute cyanide solutions (defined as milligrams per liter) will not initiate any greater release of HCN (the aquatic life criteria for cyanide are 22 and 5.2 μg/L). Temperature effects on the toxicity of cyanide reported in the literature vary with test species, life-stage of the species, concentration of cyanide, temperature range, and other conditions. Temperature decreases will increase toxicity of cyanide over long exposures to low concentrations (< 10 μg HCN/L); however, temperature increases will decrease cyanide toxicity at higher concentrations. Life stage of fish also affects the sensitivity to cyanide at varying temperatures. The LC_{50} for rainbow trout eggs increased with decreasing temperature; whereas the LC_{50} for juvenile rainbow trout decreased with decreasing temperature (Eisler, 1991). Additional studies with warm water fish (21.5°C-31.4°C), snails, insects, and plankton showed increasing toxicity associated with increasing temperature when cyanide levels ranged between 0.2-3.2 mg/L (Sarkar, 1990).

Dissolved Oxygen. Reductions in dissolved oxygen may increase the toxicity of aquatic pollutants, but are often not the major factors affecting toxicity. Most evidence suggests that tests conducted at low and high levels of dissolved oxygen may change toxicity by only a factor of 2 or less (low dissolved oxygen being generally in the range of 20% saturation). In studies where low dissolved oxygen significantly modified LC_{50}s, the same effect did not hold true for sublethal toxicity (i.e. growth). Low oxygen appears to be less important than might be expected as a modifier of sublethal toxicity. Sprague suggests that while the picture of the influence of dissolved oxygen on toxicity is incomplete, "the effects may be as small as, or even smaller, than the modest effects on acute lethality" (Sprague, 1985). From this information, it appears that when state waters comply with the dissolved oxygen standard (> 5 mg/L for warm water, > 6 mg/L for cold water), dissolved oxygen levels are unlikely to affect toxicity.

Dissolved Organic Carbon. Dissolved organic carbon can impact toxicity of some metals, such as copper. In the case of copper, as dissolved organic carbon decreases, copper toxicity increases (Sorenson, 1991). Research over the last 20 years indicates that dissolved organic carbon is important for determining metal toxicity and is especially important in rivers where dissolved organic carbon is very low (0-5 mg carbon/L). However, the studies used to develop EPA's criteria generally included water with low organic carbon, ideally representing a worst case (most toxic) scenario.

Recently, the Virginia Association of Municipal Water Agencies proposed a modification to the ambient water quality criteria for copper (Stein, personal communication, 2000). The equation is:

$$\text{Chronic criteria} = e^{(0.8545 \times \ln(\text{hardness}) + 1.27 \times \ln(\text{TOC}) - 2.903)}$$

TOC is defined as total organic carbon. This equation is based on research showing the effects of hardness and organic carbon on copper toxicity. In streams where the hardness and dissolved organic carbon are low, the copper criterion value will be very low. For example, in streams with a hardness of 20 ppm (as $CaCO_3$) and dissolved organic carbon levels of 2 mg/L, the chronic criteria would be 1.7 μg/L using the above equation. Hardness and dissolved organic carbon levels this low do occur in certain freshwater streams.

EPA criteria are developed from tests in waters with very low DOC or TOC. The Virginia equation will yield the same result as the 1995 update EPA equation if the TOC is set at approximately 2.5 mg/L. The Virginia equation was not designed to predict toxicity in waters having lower TOC, rather it was intended for waters with high TOC. BLM related work suggests that the acute tests on which EPA's criterion is based were perhaps in the range 0.5-1.0 mg/L DOC. EPA's criterion equation should be reliable to this level of DOC.

IX. STRATEGY FOR REDUCTION IN UNCERTAINTY OF WATER QUALITY CRITERIA FOR THE PROTECTION OF THREATENED AND ENDANGERED SPECIES

Bioavailability of metals and water quality conditions:

1. EPA has funded long-term research and modeling efforts to assess the speciation and toxicity of metals as they are affected by such factors as pH, dissolved organic carbon, and hardness. These efforts, known as the Biotic Ligand Model, are intended to more accurately predict the bioavailability of metals. Most of the data used to develop the Biotic Ligand Model involved copper. As part of the agreements negotiated under Section 7 of the Endangered Species Act for the consultation over the California Toxics Rule, EPA has agreed to continue development of the Biotic Ligand Model for other metals.

2. EPA Region 10 will review EPA Region 9 and Headquarters' revisions to the metals criteria based on the effect of abiotic conditions including: hardness (calcium and magnesium), pH, alkalinity, and dissolved organic carbon.

3. Idaho DEQ and EPA Region 10 will work collaboratively to develop site specific determinations for adding a margin of safety at sites where there is a realistic reason for concern that particulate metal might contribute to toxicity to T&E species that are sensitive to the metal(so) of concern.

Species sensitivity and chemical specific uncertainties

4. EPA will revise its recommended 304(a) acute and chronic aquatic life criteria for *selenium* by January 2002. In revising these criteria, EPA Region 10 will cooperate with Region 9, EPA Headquarters', and the Services. Scientists will be invited to peer review documents and participate in discussion sessions.

5. EPA, Region 10 will review the *mercury* criterion developed by EPA Headquarters', Region 9, and the State of California with respect to federally listed species in Idaho. The Services and Region 10 will determine if the criterion is protective.

6. EPA Region 10 will work with EPA Region 9 and EPA Headquarters' to review the chronic aquatic life criterion for *pentachlorophenol.* They will determine if the criterion is protective of federally listed species under varying abiotic conditions.

7. EPA Region 10 will work with EPA Region 9 and EPA Headquarters' to revise the chronic aquatic life criterion for *cadmium* so that it will be protective of salmonids by no later than January 2001.

8. EPA Region 10 will review the schedule and plan for updating the aquatic life criterion for *copper* by August 2000. The Services and EPA Region 10 will determine if the plan for updating the criteria will provide protection for salmonids.

Sediment exposure
9. EPA Region 10 will work in cooperation with EPA Region 9, EPA Headquarters', and the Services to develop sediment criterion for cadmium, copper, lead, nickel, zinc, chromium, and silver.

10. EPA is working toward resolution of the particulate metal issue through sediment criteria.

Site specific variability, dietary exposures, other routes of exposure
11. In areas where criteria are already exceeded, site specific ecological risk assessments will be completed. These assessments will be used to identify the pathways and routes of exposure for aquatic organisms in the vicinity of the potential discharge and institute site specific limits for sediment, water column, dietary, and other possible exposures.

12. EPA Region 10 will review EPA Region 9 and Headquarters' revisions to the metals criteria based on the effect of abiotic conditions including: hardness (calcium and magnesium), pH, alkalinity, and dissolved organic carbon.

13. EPA will work with the Idaho DEQ and the Services to propose a toxic chemical monitoring program. The purpose of this program would be to establish a baseline for future actions.

Wildlife exposures and chemical mixtures
14. EPA will cooperate with HQ's and other regions to develop a national methodology to derive site specific criteria to protect federally listed threatened and endangered species, including wildlife. These methods will address exposure to multiple stressors, mixtures, and abiotic driving forces (pH, temperature, dissolved oxygen, dissolved organic carbon, hardness, etc).

15. The Services and EPA have agreed on the need for wildlife criteria research and methods. The strategy for completion of this effort will be done cooperatively with EPA, the Services, academia, and other interested individuals or groups. EPA will complete a Request for Assistance on wildlife assessments. This solicitation will be released to the public by May 2000.

Sensitive life stages and surrogate species
16. EPA's Office of Research and Development is developing a research strategy to evaluate the effects of toxic chemicals on the life stages of a variety of fish, invertebrates, plants, and wildlife (1999 Draft Wildlife Research Strategy).

Bioaccumulation
17. Based on peer review and public comment, EPA has revised the methodology for deriving national bioaccumulation factors. This methodology acknowledges three chemical classes for these factors (nonionic organics, ionic organics, and inorganic/organometallics).

REFERENCES

Almack, J. R. 1985. Grizzly Bear habitat use, food habits, and movements in the Selkirk Mountains, northern Idaho. Proceedings of the Grizzly Bear Habitat Symposium, Missoula, MT. USDA Forest Service, Intermountain Research Station. General Technical Report INT-207. pp. 150-157.

Bergman, J. L. and E. J. Dorward-King (eds) Reassessment of Metals Criteria for Aquatic Life Protection. SETAC Press. Pensacola, FL.

Dallinger, R. et al. 1987. Contaminated food and uptake of heavy metals by fish: a review and a proposal for further research. Oecologia 73:91-98.

Eisler, R. 1991. Cyanide Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 85(1.23). Fish and Wildlife Service Contaminant Hazard Review.

Farag, A. et al. 1994. Physiological changes and tissue metal accumulation in rainbow trout exposed to foodborne and waterborne metals. Environmental Toxicology and Chemistry. 12:2021-2029.

Furness, R. W. and P. S. Rainbow. 1990. Heavy Metals in the Marine Environment. CRC Press, Inc. Boca Raton, Florida.

Kiffney, P. M. and W. H. Clements. 1993. Bioaccumulation of heavy metals by benthic invertebrates at the Arkansas River, Colorado, USA. Environmental Toxicology and Chemistry. 12:1507-1517.

Lemly, A. D. 1985. Toxicology of selenium in a freshwater reservoir: Implications for environmental hazard evaluation and safety. Ecotox. and Environ. Saf. 10:314-338.

Lemly, A. D. and Smith G. J. 1987. Aquatic cycling of selenium: Implications for fish and wildlife. Fish and Wildlife Leaflet #12, U.S. Fish and Wildlife Service, Washington, DC.

Pulley, T. S., Nimmo, D.W.R., and Tessari, J. D. 1998. Characterization of toxic conditions above Wilson's Creek, National Battlefield Park, Missouri. Journal of the American Water Resources Association. 34:1087-1098.

Rand, G. M. 1995. Fundamentals of Aquatic Toxicology. Taylor & Francis, Washington, D. C.

Sarkar, S.K. 1990. Toxicity evaluation of sodium cyanide to fish and aquatic organisms: Effects of temperature. Sci. Cult. 4:165-168.

Sheviak, C. J. 1984. Spiranthes diluvialis (*Orchidacae*), a new species from the western United States. Brittonia. 36:8-14.

Sorensen, E. M. B. 1976. Ultrastructural changes in the hepatocytes of green sunfish, Lepomis cyanellus Rafinesque, exposed to solutions of sodium arsenate. J. Fish Biol. 8:229-240.

Sprague, J. B. 1985. Factors that modify toxicity. In: G. M. Rand and S. R. Petrocelli (Eds.), Fundamentals of Aquatic Toxicology. Hemisphere Publishing, New York, New York. pp. 124-163.

U.S. Environmental Protection Agency (EPA). 1994. Water Quality Standards Handbook: Second Edition. EPA-823-B-94-005a. August.

U. S. Environmental Protection Agency (EPA). 1998. Guidelines for Ecological Risk Assessment. FR Notice FRL-6011-2.

U.S. Fish and Wildlife Service (FWS). 1994b. Endangered and Threatened Wildlife and Plants; The Plant, Water Howellia (*Howellia aquatilis*) Determined to be a Threatened Species, Final Rule. 50 CFR Part 17.

U.S. Fish and Wildlife Service (FWS). 1994c. Recovery Plan Selkirk Mountain Woodland Caribou (*Rangifer tarandus caribou*). USFWS Pacific Region. Portland, OR. 59 pp.

U.S. Fish and Wildlife Service (FWS). 1997b. Section 7 Guidelines - Snake River Basin Office, MacFarlane's four-o'clock (threatened), *Mirabilis macfarlanei*. Electronic file from Susan Burch to Jannine Jennings, EPA Region X, June 16, 1997. 7p.

Wildhaber, M.L. and C. J. Scmitt. 1998. Indices of benthic community tolerance in contaminated Great Lakes sediments: Relations with sediment contaminant concentrations, sediment toxicity, and the sediment quality triad. Environmental Monitoring and Assessment. 49:23-49.

Woodward, D., et al., 1994. Effects on rainbow trout fry of a metals-contaminated diet of benthic invertebrates from the Clark Fork River, Montana. Transactions of the American Fisheries Society. 123:51-62.

Woodward, D., et al., 1995. Metals-contaminated benthic invertebrates in the Clark Fork River, Montana: effects on age-0 brown trout and rainbow trout. Canadian Journal of Fisheries and Aquatic Sciences. 52:1994-2004.

Wren, C.D. and MacCrimmon, H.R. 1986. Comparative Bioaccumulation of Mercury in Two Adjacent Freshwater Ecosystems. Water Resources. Vol 20. No. 6. pp:763-769.